Satellite-based analysis of Carbon Monoxide and Fires in the Arctic

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Background

- Climate change proceeds fastest in the Arctic region
- Arctic summers have become warmer and drier
- The past 3 summers in the Siberian arctic have been about 2-7°C warmer than 1981-2010 average

Credit: http://www.karstenhaustein.com/climate.php
Data used

• Carbon monoxide (CO) total column
  • TROPOMI
• Fire Radiative Power
  • MODIS Collection 6 (NASA DAAC)
Validation of TROPOMI CO

- Against Sodankylä TCCON instrument TROPOMI shows overestimation of about 10% with <10% standard deviation in single measurement comparison.

- Spatial averaging brings standard deviation to approximately 5%.

- In this study we have used a 50x50 km grid.
Spatial evolution of fires in the Arctic using MODIS FRP-data

Difference in yearly amount of detected fires, June to August, 2012...2020 - 2003...2011
Spatial evolution of fires in the Arctic using MODIS FRP-data

Difference in yearly amount of detected fires, June to August, 2012...2020 - 2003...2011
Monthly means summer 2018

Monthly sum of Fire Radiative Power, 2018-6

Monthly sum of Fire Radiative Power, 2018-7

Monthly sum of Fire Radiative Power, 2018-8

Monthly sum of Fire Radiative Power, 2018-9

Monthly mean CO mixing ratio, 2018-6

Monthly mean CO mixing ratio, 2018-7

Monthly mean CO mixing ratio, 2018-8

Monthly mean CO mixing ratio, 2018-9
Monthly means summer 2020
Area of interest, Arctic Siberia
Monthly summary of selected areas
A lot of CO transported from south of 60° N
Monthly summary of selected areas

Exceptional amount of fires in the Eastern area.

Late fires in September seem to rise also the October CO-levels.
Summary

• The number of wild fires has risen in the Arctic Siberia
• Fires could affect atmospheric carbon balance in several ways
  • Direct carbon dioxide and carbon monoxide release
  • Methane release from thawing wetlands; enhancement because of the heat of the fires and lower albedo of burnt areas causing more radiation absorption by land
  • Shrinking of atmospheric sink because of large CO-emissions
• Satellites provide valuable information on large scale processes; in this case tracing the CO helps us identify wild fire emissions and their transport
Aknowledgments

• The work is related to PEEX- the Pan Eurasian Experiment
  • Multidisciplinary climate change, air quality, environment and research infrastructure, focused on Northern Eurasian, particularly Arctic and boreal regions.
Extensive scientific infrastructure in Sodankylä that could support Peex-related research

**Measurements: atmosphere**
- Soundings, radar, lidar and spectrometry
- Ozone columns and profiles
- CO2, CH4 and energy exchange between atmosphere and ecosystem
- Total column observations (CO2, CH4, N2O, HF, CO, H2O, HD0)
- CH4, CO2, CO, vertical profiles
- Precipitation, meteorology
- Radiation

**Measurements: dynamic 3D surface quantification**
- Continuous 3D laser scanning
- Vegetation state and growth
- Snow cover

**Measurements: Satellite cal/val**
- Ground-based, drones and sounding
- Passive microwave (radiometer)
- Active microwave (radar)
- Optical/IR
- Lidar
- Snow cover
- Vegetation & soil processes
- Solar induced chlorophyll Fluorecence
- Atmospheric gases and aerosols
- Radiation
- Meteorological observations

**Ecosystem processes (summer)**
- **Water bodies (lake/river)**
  - CO2 / CH4 exchange
  - Water level
  - Surface temperature
  - Sensible and latent heat exchange
- **Wetland**
  - CO2/CH4 exchange
  - Long-term greening
  - Plant phenology
  - Water level
  - Sensible and latent heat exchange
- **Forest**
  - CO2 exchange
  - Long-term greening
  - Plant phenology
  - Soil humidity
  - Sensible and latent heat exchange

**Ecosystem processes (winter)**
- **Forest**
  - Snow - soil – forest interactions
  - Snow Water Equivalent
  - Soil freezing
- **Wetland**
  - Snow – soil vegetation interactions
  - Snow Water Equivalent
  - Soil freezing
- **Water bodies (lake/river)**
  - Snow - ice interactions
  - Freezing